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Design for Sustainable Architecture and
Environments

Behzad Sodagar, Rosemary Fieldson and Bryce Gilroy-
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Design for Sustainable Architecture and Environments

Behzad Sodagar, University of Lincoln, Lincolnshire, UNITED KINGDOM

Rosemary Fieldson, Simons Group, Lincolnshire, UNITED KINGDOM

Bryce Gilroy-Scott, Hill Holt Wood Social Enterprise, Lincolnshire, UNITED KINGDOM

Abstract: This paper describes some of the research outcomes of a Knowledge Transfer Partnership (KTP) project partly funded by Department of Trade and Industry, UK. One of the aims of the project was to plan and develop designs for a range of autonomous eco-buildings through research into autonomous eco-building systems and techniques in order to identify best practice and the most appropriate systems for low-carbon buildings. The design of the Community Hall offering accommodations for a multi functional hall, café and exhibition, and offices, has been developed through partnership with mainstream design and construction companies in the region. Following a successful planning application and external fund raising exercise, the construction of the building is due to start shortly. The structure will be constructed using locally sourced materials and is designed to be 'renewable' whilst exceeding all the requirements of the current Building Regulations. It examines the potential of non traditional construction techniques and materials. The total environmental impact of the design as the result of environmental loads occurring during the life span of the building is estimated and compared with conventional practice. The building incorporates rain water collection, waste treatment, composting toilets and photovoltaics.

Keywords: Sustainable Design and Construction Autonomous Buildings, Renewable Energies, Embodied and In-Use Energy, Carbon Footprinting, Whole Life Cycle Analysis

Introduction

IT IS NOW widely accepted that climate change is happening and that human activity is responsible for global warming. The first UN Conference on the Human Environment (UNCHE) took place in 1972 and succeeded in bringing environmental issue into international agenda. In 1987 the so called Brundtland Commission Report stated the most widely accepted definition of sustainability as "development that meets the needs of the present without compromising the ability of the future generations to meet their own needs" (Edwards and Hyett, 2001). The Rio Earth Summit in 1992 attempted, with some degree of success, to identify the requirements of achieving sustainable development. Further world summits including Johannesburg in 2002 and Bali in December 2007 have tried to arrive at agreements to safeguard the environment and to formulate policies for sustainable planning and development. Although the Bali conference failed to establish targets, it managed to convince all governments that immediate measures must be taken in order to prevent catastrophic environmental consequences.

The above summits have identified the building industry as a major contributor to environmental problems. The industry consumes 40% of the materials entering the global economy, and is responsible for almost half of the global greenhouse gases (Asif, Muneer, and Kelly, 2007). In order to lessen the environmental impact of buildings, regulations and

standards on energy efficiency measures and use of renewable energy sources are becoming a more visible priority in European Union policy. According to the Commission's Green Paper of 2006 on energy efficiency, EU energy consumption could be cut by around 20% (Cadima, 2007).

In response to the challenge of climate change, the UK has adopted some ambitious targets in order to reduce energy demand of buildings resulting in their reduced CO₂ emissions. The Code for Sustainable Homes (Department for Communities and Local Government 2007) has generated a lively debate regarding whether it is realistic for buildings to be carbon neutral. Regardless of the ultimate resolution of this debate, it is certain that the energy required for building operations must decline with improved energy efficiencies and building design. Therefore the potential energy fraction contributed by renewable energy will be proportionally increased. It is essential that architects and other design professionals have an in-depth and technical understanding of the possibilities and the limitations of these technologies.

Towards Sustainable Architecture and Environments

Defining sustainable planning and development as a philosophy will help the understanding and identification of the most appropriate approaches to maximize quality and minimize the environmental impact



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of developments (Sodagar, et.al. 2006). Sustainable buildings are prerequisite to the creation of sustainable communities in which people will be happy to live; their needs and aspirations are met without damaging their environment or causing problems for other communities or future generations (McLennan, 2004). Edwards and Hyett (Edwards & Hyett, 2001) define sustainable construction practice as; "Architects, builders and engineers who can create useful social products (buildings) using the minimum of resources so that future generations have their share". The philosophy of sustainable planning and development is therefore not only a question of designing for energy efficiency.

Different terms are being used for sustainable design including 'green architecture' 'climate responsive architecture', 'high-performance' and similar terms (Kibert, 2005). Kibert concludes that all have one key objective; to apply principles through the entire life cycle of construction, from planning to disposal. One of the fundamental principles of sustainable architecture is that it should work with and not against nature. It should aim to achieve the maximum use of ambient energy sources in the creation of internal environments that are, as far as possible, naturally sustained. It is important to realize that in order to achieve a sustainable architecture, an integrated approach to design is required and appropriate design strategies must be formulated at the outset.

Sustainable architecture should be logical in its use of technology. Technology must be subservient to design and not a goal. While some buildings may use low-tech solutions to achieve their goals, intelligent systems and elements may require specification under special circumstances.

For a building to be sustainable, it must respond to the social and economic conditions of the context within which it exists. It also needs to respond to possible future changes in its use which may happen due to different future socio- economic conditions. A building therefore should be flexible and adaptable.

Whole Life Cycle Analysis

In order to achieve a truly sustainable construction, all the environmental impacts of buildings must be considered. The total environmental impact of a building is the result of environmental loads occurring during the life span of the building. These are; initial impact, annually repeating impact and deconstruction impact (van den Dobbelsteen and van der Linden, 2005). The initial impact is caused during the design and construction of the building including the project management activities, material use, construction processes and waste. The annually re-

peating impact is the result of energy use for heating, lighting, ventilating and cooling and the repairs and refurbishments occurred during the usable life of a building. The final stage, the deconstruction, happens when the building is demolished.

Methodologies and evaluations tools exist to assess the environmental impact of designs and buildings. In the UK the widely used method is BREEAM -Building Research Establishment Environmental Assessment Method which may be used to evaluate the environmental impact of buildings (BREEAM, 2006).

Design Development of a Sustainable Community Hall

A two year Knowledge Transfer Partnership (KTP) partially funded by Department of Trade and Industry (DTI) was concluded in August 2007 with Lincoln School of Architecture and Hill Holt Wood (HHW) as knowledge and commercial partners respectively. One of the aims of the KTP project was to plan and develop designs for a range of autonomous eco-buildings, starting with a Woodland Community Hall on the 32-acre Wood site of HHW in the East Midlands, UK.

The design of the Community Hall was generated as a student design competition in Studio 4 at the Lincoln School of Architecture under supervision of the first author of this paper (B Sodagar, 2007). Simons Design, part of Simons Group, became involved in the project and assisted with obtaining detailed planning permission for the scheme. The project has succeeded in securing additional external funding of £257,500 so far towards the construction cost of the building which is planned to start in February 2008. Simons Design was awarded the 2007 'Business and Community Award' for its pro bono involvement in the project while the University and Hill Holt Wood were granted the 'KTP Outstanding Award'.

Building Arrangement

The Community Hall offers facilities for meetings, conferences, and social activities. The building is split into three use groups; the Hall, the Link and the Black Box. The interior spaces are organized in a way to offer a high level of adaptability. (Figures 1,2,3,4,5 and 6).

The circular Hall is designed to accommodate up to 50 people. Its walls are rammed earth with soil obtained from the site and insulated with cork. The excavation required to provide the soil will allow construction of pond areas adjacent to the structure for amenity purposes. The Hall roof will incorporate a timber Reciprocal Frame three-dimensional grillage

which is constructed using mutually supporting beams to form a closed circuit (Figure 7). The timber will be extracted from Hill Holt Wood and other local woodlands managed by Hill Holt.

The foundations of the entire building will be made from limecrete. Limecrete is an experimental material in terms of its use as mass structural materials in construction in the UK. The Limecrete formulation will be based on a Natural Hydraulic Lime, strength grade 5. This material has achieved compressive strengths of up to 19 N/mm^2 in laboratory testing. The limecrete aggregate will be a primary material obtained locally and the 250mm raft foundation will be steel reinforced. It has been calculated that the material offers approximately 21% CO_2 reduction per m^3 over standard C20 concrete using Ordinary Portland Cement (Lime Green Ltd. Report to Client, January 7, 2007).

The small slab underplaying the composting toilets will use Ground Granulated Blastfurnace Slag (GGBS) as the binding agent as the resulting concrete will be less permeable than a standard concrete and using the GGBS is recycling an industrial by-product that otherwise would be treated as waste.

The Link, with a sedum roof and largely glazed walls, houses the café and exhibitions. This construction will provide a tempered environment to staff, trainees and visitors with doors standing open in summer months to achieve an out door – indoor space.

The Black Box houses a plant room, kitchen and ancillary offices and is constructed in highly insulated timber construction with a photo-voltaic tiled roof. Photovoltaic cells generate most of the electricity for the building. The ground floor of the Black Box includes three building-integrated dry composting toilets.

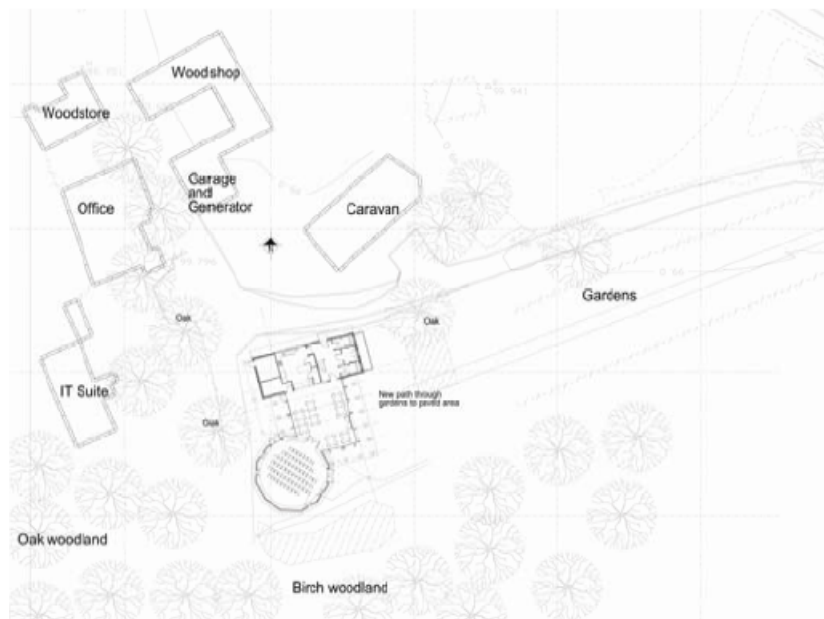


Figure 1: Site plan

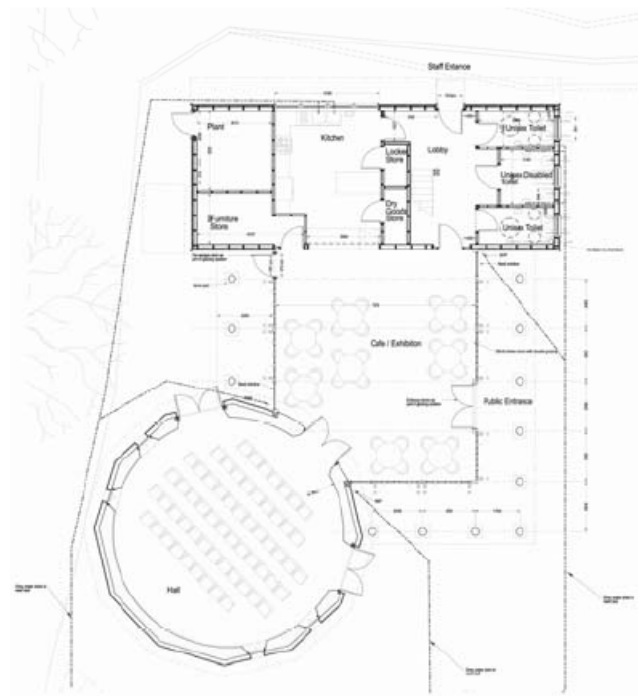


Figure 2: Community Hall – Ground Floor Plan

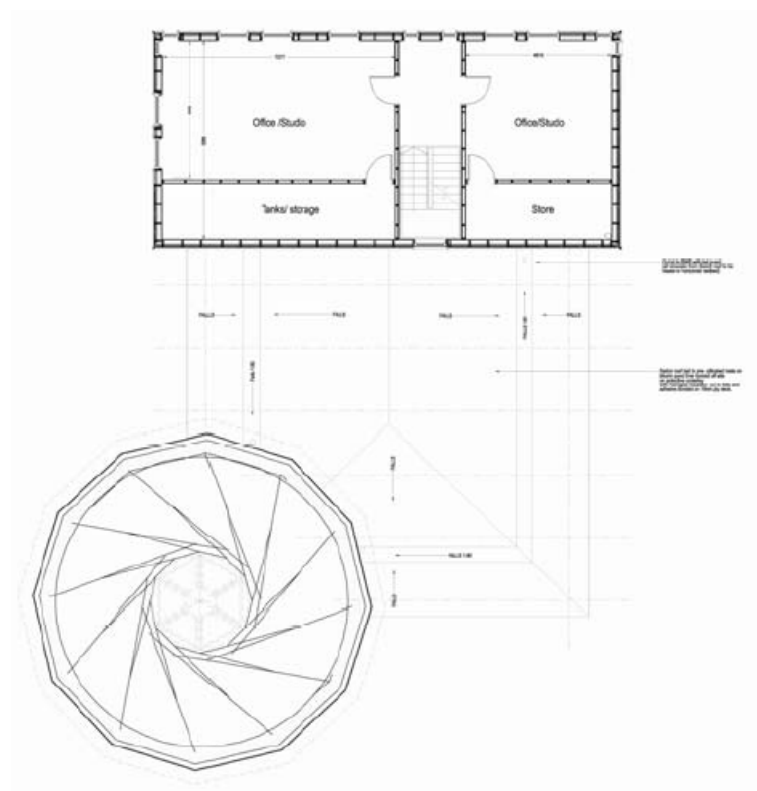


Figure 3: Community Hall -First Floor Plan

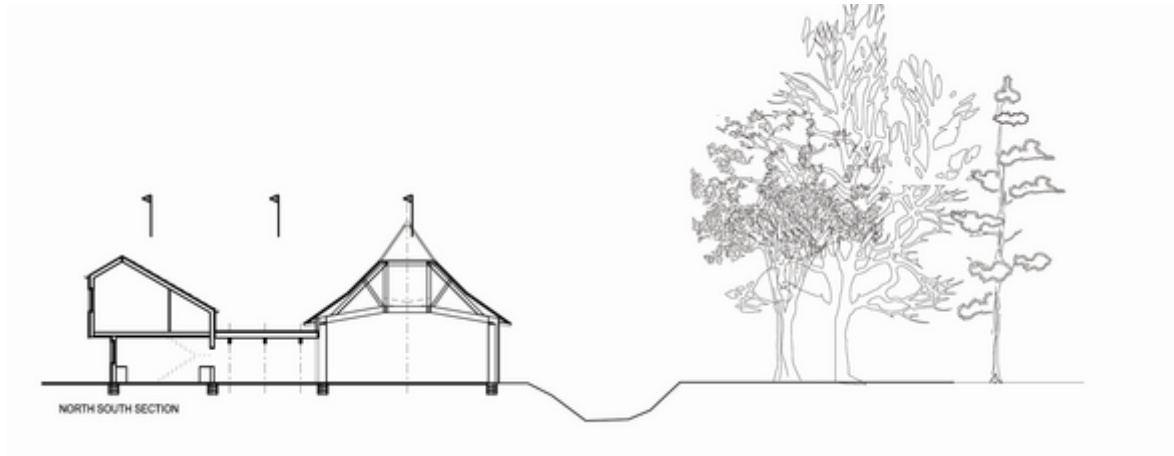


Figure 4: Community Hall – North South Section

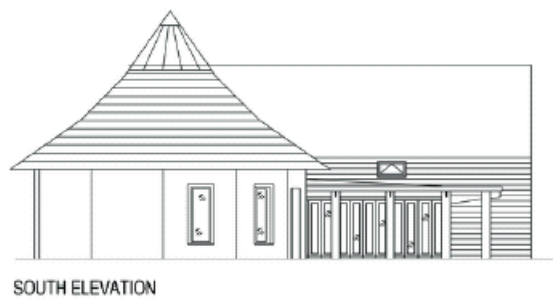


Figure 5: Community Hall - South Elevation

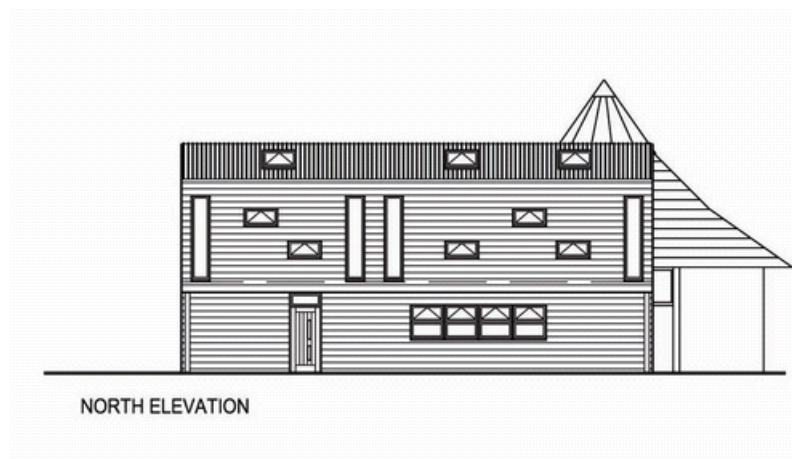


Figure 6: Community Hall - North Elevation

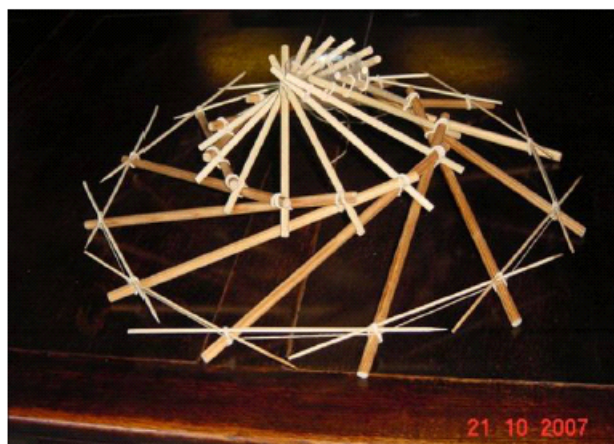


Figure 7: Structural Model for the Reciprocal Roof

Environmental Philosophy

The design of the building is based on principles of passive solar design. The design attempts to fully

utilize natural light, ventilation, thermal mass and insulation. It also incorporates rain water collection, waste treatment and renewable energies. Table 1 highlights material specifications and estimated U-values.

Table 1: Materials specifications and U – Values

Zone	Component	U-value WK/m ²
Office	Wall (Timber with timber cladding)	0.08
	Roof (Timber with clay tiles)	0.08
	Floor (limecrete with terracotta tiles)	0.19
	Windows (Wooden frame triple glazed)	1.2
Hall	Wall (Insulated rammed earth)	0.18
	Roof (timber reciprocal roof with singles)	0.09
	Floor (limecrete with terracotta tiles)	0.19
	Windows (Wooden frame triple glazed)	1.2
Cafe	Wall/windows (wooden frame double glazed)	2.26
	Roof (Earthed timber with Sedum)	0.15
	Floor (limecrete with terracotta tiles)	0.19

A series of computer simulation modelling using ECOTECT (Square One) have been performed to analyze energy performance of the design. Monitoring stations will be embedded into construction of the building to measure surface and interstitial temperature gradients together with moisture contents of materials. Internal and external ambient conditions will also be recorded.

Calculated monthly heating loads are shown in figure 8. The Community Hall building is a multi functional one and hence may be used by different user groups including the elderly and children. It is assumed that the space heating should be provided

throughout the year in areas which may be used by the public. The calculated space heating demand in the first floor office to keep the temperature above 19°C is only 34 KWh from May to September. It is therefore assumed that this heating circuit may be switched off during the summer in this zone. The total annual space heating load for the building is 6825 KWh. The total gross internal floor area of the building is 297 m² giving a figure of 23KWh/m²/year. The heating demand for “Good Practice” community centres is reported to be in the order of 125KWh/m²/year while that for “Typical Practice” being 187KWh/m²/year (CIBSE, 2004).

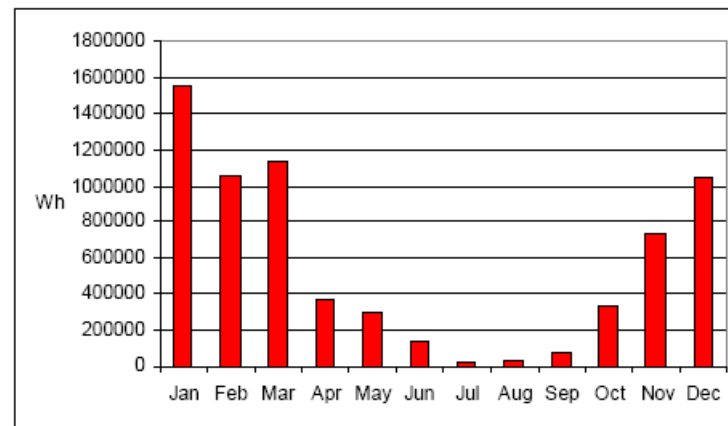


Figure 8: Monthly Heating Loads for the Whole Building

Construction Philosophy

A whole life emissions reporting exercise has been carried out to investigate the effect of material specification and substitution on the CO₂ emissions of the design.

The introduction of AD Part L 2006 (ODPM, 2006) has focused attention onto CO₂ emissions during the operational phase of buildings. However, as successive improvements are made in services design to meet the current regulations and in order to obtain “A” ratings in Energy Performance Certificates (EPBD, 2002) to be introduced in the UK in 2008, embodied energy becomes a more significant issue. As Hill Holt Wood was intended to have very low operational emissions due in part to efficient design and also high dependence on renewable technologies, materials emissions are considered as a significant part of the design process.

Specification Criteria

The fabric of Hill Holt Wood was designed to meet a number of criteria;

1. To minimize environmental impact from a broad range of indicators
2. To minimize transportation to site (local sourcing)
3. To minimize operational energy via appropriate thermal performance
4. To minimize heat loss through very high insulation standards
5. To demonstrate a wide range of technical solutions meeting these criteria (learning tool)

The primary driver was that the building would be low carbon in construction and use. Demonstrating that this was true required carbon footprint analysis for the construction process and comparing this to energy modelling for operation emissions.

Methodology for Carbon Footprinting

Carbon footprinting of the construction process is a new indicator for construction efficiency and few statistics are available nationally, it is based on Supply chain methodology (Carbon Trust, 2006). The whole life carbon emissions of a building are made up of the sum of;

1. Project management
2. Materials
3. Construction process and waste
4. In-use
5. Deconstruction

Each of these stages are made up of further calculations and models, stages 1-3 can be estimated at the outset and then measured as they occur. Stage 4 may be estimated using predictive techniques but can not be measured accurately until several years of occupational data is collected. Stage 5 is also an estimate, and it is hoped that research in the deconstruction of buildings may help to refine current estimating accuracy for deconstruction 40-60 years in the future.

This process borrows principles from cost estimating in construction and Whole Life Costing methodology (WLC). WLC in particular uses net present values to give perspective to financial value over time. The impact of carbon dioxide emissions are assumed to remain the same in the future as they are given now, this is not necessarily true in reality, but is relatively a safe assumption as we cannot estimate the changes which might occur to factors such as conversion rates of energy mix over the long term. Gross built areas is used to provide m² rates in all stages except *In-use* which uses gross internal areas as set out in National Calculation Methodology and Simplified Building Energy Model (BRE, 2007).

Project Management

Obtaining data for the management of the design and construction process is straightforward as a share of consultants' office and transport emissions which are attributed to the project. These can be calculated using conversion factors and methodology such as DEFRA (DEFRA, 2007). Whilst this is a simple calculation, documentation over the long term can be problematic. This part of the footprint has been estimated as 3 tonnes based on frequencies and locations of design meetings over a two year period.

Materials

Emissions data for materials used in the construction of a building can be obtained from a number of European sources. The Bath Carbon Inventory

(Hammond and Jones, 2006) provides generic data for a wide range of materials used commonly in the UK. Demand for disclosure of emissions data in the building products manufacturing industry is leading to a competitive market for product declarations. A UK standard is anticipated from research currently being carried out by the Carbon Trust and BSI (BSI, 2007).

Table 2 lists a breakdown of CO₂ emission for the HHW community building. The data is represented in figure 9 showing the relative CO₂ contribution for different elements of the construction. The gross built area of Hill Holt Wood is 341m². The materials emissions rate is 332.27kg CO₂/m² much less than we might expect for a conventionally constructed building with a similar function at 800-1200kgCO₂/m². (Based on unpublished project analysis by Simons Group in 2007).

Table 2: Breakdown of CO₂ Emission of Construction

Product and material packages	CO ₂ emissions in kg
Substructure (limecrete)	21012
Waterproofing	2770.04
Steel	209.3
Timber	6617.9
Wall cladding	14348.66
Roof	17482.3
Externals sundries	2000
Masonry walls	4826.256
Fire stoppings	417.5
Windows	15404.59
Doors	5080.65
Internal walls	1357.8
Floors	8377.108
Ceilings	2323.2
Fixtures	1077.25
M&E Installation	10000
Total embodied energy	113304.554

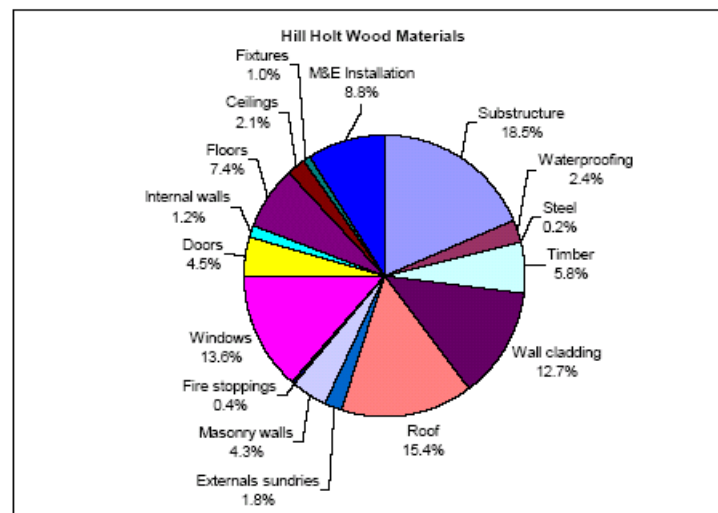


Figure 9: CO₂ Emission Contribution of different Elements

Accurate bills of quantities are fundamental to calculating the quantities of materials. In a conventional building, it would be expected that the substructure including in-situ concrete represents around a third of the materials emissions.

Many of the materials have been calculated on the basis of generic UK supply data from the Bath Carbon Inventory (Hammond and Jones, 2006). This is a limited inventory giving a range of figures for generic materials, more accurate data for specific products can be obtained from some suppliers, with limited levels of comparability in calculation. This data base is not applicable when utilizing home grown or site sourced materials such as timber shingles and cladding, and reclaimed materials such as plaster board off-cuts, stone and brick. Taking these materials into account is difficult to calculate, supply of each quantity and work package must be documented as the construction programme progresses and it is necessary to assume the generic rate until work is completed. Mechanical and electrical plant is also an area with limited available data, an assumption has been made to cover the large area of photovoltaics integrated in the roof (Hammond and Jones, 2006) and conventional services required for lighting heating and small power.

Construction Process

BREEAM(2006) assessment requires that fuel, transport to site, water and waste are monitored, although recording of these areas of resource use are not regulated in any way. Current best practice advocates surveying all incoming and outgoing vehicles for distance travelled and engine type to obtain emissions data and recording delivered fuel and water and meter readings. Many larger construction sites in the UK now use waste handling contractors who are able to provide detailed breakdowns of waste

removed and quantities that have been separated for recycling. Published conversion factors for specific waste types are limited, however at Hill Holt Wood, all waste from the build will be utilized in some way, for landscaping, maintenance of other buildings and used as teaching aids for young learners on site, therefore waste is assumed to be zero.

The fuel and transport strategy for the construction process of Hill Holt Wood should demonstrate savings against a conventional building construction process particularly as much of the work will be manual, however an estimate has been assumed until actual results are compiled at completion of the build. Simons Group have found that a commercial non-mains connect site can use around 34kgCO₂/m² (Fieldson and Smith, 2007). This is based on a much larger building site with economies of scale for deliveries. An estimated total of 12tCO₂ has been assumed to cover plant used on site such as diggers and chainsaws, deliveries of materials to site, workforce travel and subcontractors direct emissions for installation.

In-Use Energy and Systems

Hill Holt Wood is an autonomous site, therefore there are no mains services into the Wood. The Woodland Community Hall project has been based on the premise of producing an exemplar low energy building that is self-sufficient to the greatest degree possible, for its provision of heat and power, as well as for building services such as water and sewerage.

The calculated potential rainfall that could be harvested by the 183m² of surface area suitable for rainwater capture, at an assumed Coefficient of Performance (due to evaporation and splash losses) of 70%, results in an annual resource of 76,950L.

The reedbed system design is for an ecological sanitation system that has a surface area of 6.25m²

and a depth of 500-700mm. The reedbed will be situated adjacent to the composting toilets as this is the area closest to the two wastewater generating areas of the building and the site gradient naturally flows to this location.

The energy demand of 23KWh/m²/year for heating will be met by a biomass boiler. On-site roof mounted PV cells with ancillary battery storage capacity will provide electricity. The roof area is sufficient for a 12 KWp (kilowatt peak, therefore its theoretical peak generating capacity is 12 KW) array. The remaining electrical demand will be met by a biofuel generator and in the future biogas for catering needs. The best efficiency in this context would be a micro-combined heat and power (CHP) system that captures the heat produced by the electricity generator.

All of these are classed as low to zero carbon technologies giving an annual emission rate of less than 1kgCO₂/m²/year. In-use emissions are normally calculated in line with the definition of building services established for the purposes of meeting the requirements of the Energy Performance in Buildings Directive (EPBD 2002) with building efficiency rates calculated by SBEM for Building Control approval and Energy Performance Certificates, and excluding small power use. This is not an accurate measure of the energy that will actually be consumed by a building, but is a nationally recognized method that provides a good standardization of the demands that form the building services. The design life used in the assumption is 60 years. The whole life emissions due to In-Use energy will therefore be around 18 tonnes (1kgCO₂/m²/year * 297 m² gross internal floor area* 60 years).

Deconstruction

Documenting deconstruction of a building at the end of its life is a speculative matter as we are unable to make accurate assumptions regarding the market and possibilities for recycled materials in 60 years time. Hill Holt Wood have made the assumption that disposal of most of their building could be dealt with on site through combustion, composting or recycling into new building materials which though sustainable does not offer any identifiable credits for the emissions embodied in the construction. A nominal sum of 4 tonnes has been used but any certainty is difficult.

Whole Life Emissions (WLE)

The WLE of Hill Holt Wood over 60 years is 150tCO₂ or 440kgCO₂/m² (gross floor area 341m²). Table 3 lists emissions due to different attributes while Figure 10 represents the emission contribution of different elements. With limited published case studies of this nature to make comparisons, it is difficult to establish that this is an ultra low carbon building.

The calculations must be repeated on completion of the project, to take into account all variations that occur in design and specification and include actual data from fuel in equipment and transport during construction. This final calculation will provide the supply chain carbon footprint for the building as completed product.

Table 3: Estimated Whole Life Emissions (WLE) for the HHW Building

	tCO ₂
Project Management	3
Materials	113
Construction process	12
In-Use energy	18
Deconstruction	4
Total	150

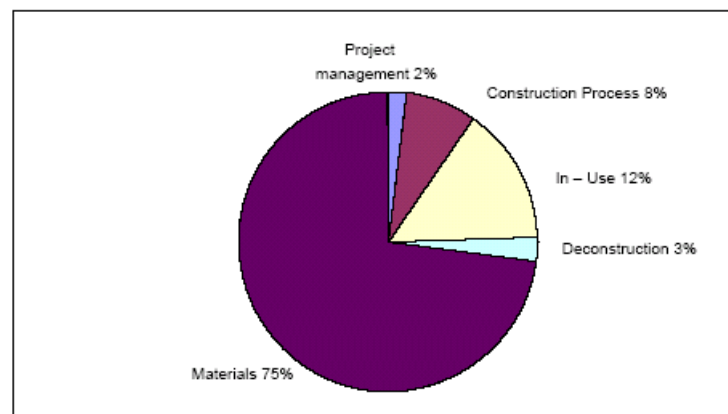


Figure 10: Whole Life Emission over 60 Years

Conclusions

The importance of this method of calculating emissions from a building is that the construction industry is a major contributor to the total UK CO₂ emissions output. Focusing on operational emissions is only half of the story, the start and end of a building's life can have such a significant contribution on environmental impact that a building must operate for more than 20 years to offset this imbalance (Lane, 2007). The reduction demonstrated at Hill Holt Wood provides a case study of an exceptionally stringent emissions reduction strategy that hopefully will be drawn into mainstream design and construction.

Further work, researching methods to address confidence levels and availability of conversion factor data for materials and estimation accuracy for construction process fuel and transport use, will help to determine relationships between construction methods and materials and how these relate to operational energy. Publication of case studies is vital to this process.

Key learning from carbon foot printing in design and construction:

1. Bill of Quantities is essential to calculating the materials emissions

2. Early integration with services design will provide the maximum opportunity for emissions reduction
3. Ability to model base design on generic materials will establish the basic footprint
4. Identify largest impacts and work to reduce by substitution of materials
5. Incorporating more accurate data from suppliers for a specific product or material where available
6. Ability to compare with measured energy use and waste data from construction monitoring is necessary to establish how process and content in the build are related
7. Accept that the entire carbon footprint cannot be measured and will not be accurate for stages in the building life that are yet to take place

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References

- Asif, M., Muneer, T. and Kelly, R. *Life cycle assessment: A case study of a dwelling home in Scotland*, Building and Environment 42 (2007), 1391, 2007.
- BRE, National Calculation Method, 2007. <<http://www.ncm.bre.co.uk/index.js>>, [accessed 29 January 2008].
- BREEAM, 2006, <www.breeam.org> [Accessed 12 December 2007].
- BSI, Consultation, 2007. <<http://www.bsi-global.com/en/Standards-and-Publications/How-we-can-help-you/Professional-Standards-Service/PAS-050/>> [accessed 29 January 2008].
- Cadima, P. *The European Strategy Toward Sustainability in the Built Environment*, PLEA 2007, Sun, Wind and Architecture, 24th International Conference on Passive and Low Energy Architecture, 22-24 November 2007, Singapore, 2007.
- Carbon Trust, *Carbon footprints in the supply chain; the next step for business*. UK, Carbon Trust, 2006.
- CIBSE Guide F: *Energy efficiency in buildings*, 2004.
- DEFRA, Guidelines to Defra's GHG conversion factors for company reporting, London, Defra, 2007. <www.carbontrust.org> [accessed 29 January 2007].
- Department for Communities and Local Government, *Building a Greener Future: policy statement*, London, Crown, 2007.

- Directive 2002/91/EC of the European Parliament and of the Council on the energy performance of buildings, 16 December 2002.
- Edwards, B. and Hyett, P. *Rough Guide to Sustainable Design*, UK, RIBA Publications, 2001.
- Fieldson, R. and Smith, B. *Gathering Diverse and Complex Energy Use Data for Monitoring and Analysis*, conference proceedings, London Business Conferences 17-18 September, London, 2007. <<http://www.simonsgroup.com>> [accessed 29 January 2008].
- Hammond, G. and Jones, C. *Inventory of Carbon and Energy*. Version 1.5Beta Bath: University of Bath, 2006 [available from <http://people.bath.ac.uk/cj219/>].
- Kibert, C. J. *Sustainable Construction Green Building Design and Delivery*, New Jersey, John Wiley & Sons Inc, 2005.
- Lane, T. *Our Dark Materials*, Building, Issue 45, 2007. <<http://www.simonsgroup.com>> [accessed 29 January 2008].
- McLennan, J. F. (2004) *The Philosophy of Sustainable Design*, USA: Ecotone, 2004.
- Office of the Deputy Prime Minister – ODPM, *Building Regulations Part L (Conservation of Fuel and Power)* London: ODPM, 2006.
- Sodagar, B., Chilton, J., Gilroy Scott, B., Lowthrop, N. and Fieldson, R. *Design Development for a Community Hall: the Architecture of a Sustainable Building in Lincolnshire*, Construction Information Quarterly (CIQ), Chartered Institute of Building (CIOB), Vol. 9, Issue 1, 2007.
- Sodagar, B., Chilton, J., Gilroy Scott, B. and Lowthrop, N. *Integration of teaching and research: design development for a range of autonomous buildings*, PLEA 2007, Sun, Wind and Architecture, 24th International Conference on Passive and low Energy Architecture, 22-24 November 2007. Square one, www.squ1.com.
- van den Dobbelsteen, A.A.J.F. and van der Linden, A.C., *Managing the time factor in sustainability – a model for the impact of the building lifespan on environmental performance*, In *Smart & Sustainable Built Environment*, edited by Yang, J., Brandon, P.S. and Sidwell, A.C., Blackwell Publishing, 2005.

About the Authors

Dr. Behzad Sodagar

Dr Sodagar is a senior lecturer in Architecture at Lincoln School of Architecture and has almost thirty years experience as an architect, researcher and lecturer working for a variety of public and private organisations and universities. He has a wide ranging expertise in sustainable planning and development and sustainable architecture. Dr. Sodagar has undertaken research and consultancy for a wide range of national and international organisations including the International Energy Agency, British Research Establishment, Department of Trade and Industry, Carbon Trust, and local and regional organisations and governments. He has extensive experience in the development of methodologies for appropriate use of computer simulation programs and their use as assessment tools to analyze the impact of design and construction on environmental performance of building, embodied energy and carbon-footprinting affecting climate change. He has widely published in sustainable planning and development, sustainable architecture and environmental design of buildings. He was awarded the International Award for Excellence by The International Journal of Environmental, Cultural, Economic and Social Sustainability for the Best Paper of the year in 2006.

Dr. Rosemary Fieldson

Rosemary Fieldson is a Senior Project Architect at Simons Design. She developed an interest in sustainability in her BA degree at University of Newcastle in the early 1990's, following graduating from the BArch course she worked for Ken Yeang in Kuala Lumpur whilst working on a Masters Thesis on the Aesthetics of Environmentalism. Returning to the UK in 1998 for a years work in a small prestige domestic design practice in London and then to Simons Design in Lincoln to specialise in retail architecture, Rosemary commenced reading for a part time PhD in 2001, entitled "Towards A Framework for Sustainability in UK Retail Architecture" which has been awarded and will be submitted in January 2007. Rosemary enjoys part time undergraduate teaching at both Lincoln and Newcastle alongside continuing to develop the profile of sustainable design for Simons Group.

Bryce Gilroy-Scott

Bryce Gilroy-Scott completed his undergraduate degrees at the University of Victoria, Canada in the early 1990's followed by several years work with community development projects. He completed a Certificate in Community Economic Development at Simon Fraser University, Canada in 2002 followed by a year of fieldwork in Central America. He has recently completed his MSc Architecture: Advanced Environmental and Energy Systems from the University of East London and the Centre for Alternative Technology with distinction. He is the Knowledge Transfer Partnership Associate between Hill Holt Wood and the University of Lincoln and is currently the Sustainability Manager at Hill Holt Wood. He is also reading for his MA Architecture: Development and Regeneration at the University of Lincoln.

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